RECENT ADVANCES IN PHASE-FIELD MODELS OF FRACTURE INCORPORATING ARBITRARY MATERIAL STRENGTH

Yangyuanchen Liu, Oscar Lopez-Pamies, and John E. Dolbow

ABSTRACT

We discuss several recent advances in phase-field models of fracture that illustrate the importance of accurately representing material strength. We begin with a study of crack nucleation from V-notches in quasi-brittle metallic alloys [1] that has proven particularly challenging for model validation. Results are shown for both a well-established model for brittle materials as well as a recently-developed phase-field model for ductile failure. The results illustrate how model calibration based on an energetic threshold for nucleation simply fails to reproduce the results across the full spectrum of V-notches. Instead, our analysis indicates that a stress envelope is capable of adequately explain nucleation, and that any complete theory of phase-field fracture must account for arbitrary material strength.

As an illustration of the utility of such a theory, I will share recent results from an analysis of the Brazilian test [2]. The test is used as an indirect means to measure the tensile strength of brittle materials. It is a challenging problem for standard phase-field models of fracture, because it involves crack nucleation under large, primarily compressive stress fields. By allowing for an arbitrary strength surface, the model allows for a complete investigation of this now standard test for strength. Importantly, it explains why cracks occasionally nucleate at the boundaries of the specimens as opposed to the interior. Results from simulations of dynamic, brittle fracture that illustrate the importance of strength will also be shown. Finally, I will share a recent result [3] that illustrates how the model employed in Kumar et al. [2] can be recast as a variational theory.

REFERENCES

[1] T. Hu, J.E. Dolbow, and Z. Yosibash, 2022. Towards validation of crack nucleation criteria from V-notches in quasi-brittle metallic alloys: Energetics or strength? Computer Methods in Applied Mechanics and Engineering **402**, pp. 115419.

[2] A. Kumar, Y. Liu, J.E. Dolbow, and O. Lopez-Pamies, 2024. The strength of the Brazilian fracture test. Journal of the Mechanics and Physics of Solids **182**, pp. 105473.

[3] C.J. Larsen, J.E. Dolbow, and O. Lopez-Pamies, 2024. A variational formulation of Griffith phase-field fracture with material strength. International Journal of Fracture, submitted.